

INTERNATIONAL STANDARD



**Fixed capacitors for use in electronic equipment –
Part 21: Sectional specification – Fixed surface mount multilayer capacitors of
ceramic dielectric, Class 1**



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IEC 60384-21

Edition 4.0 2024-06
COMMENTED VERSION

INTERNATIONAL STANDARD



**Fixed capacitors for use in electronic equipment –
Part 21: Sectional specification – Fixed surface mount multilayer capacitors of
ceramic dielectric, Class 1**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 31.060.10

ISBN 978-2-8322-9278-5

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FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –**Part 21: Sectional specification –
Fixed surface mount multilayer capacitors of ceramic dielectric, Class 1****FOREWORD**

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This commented version (CMV) of the official standard IEC 60384-21:2024 edition 4.0 allows the user to identify the changes made to the previous IEC 60384-21:2019 edition 3.0. Furthermore, comments from IEC TC 40 experts are provided to explain the reasons of the most relevant changes, or to clarify any part of the content.

A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text. Experts' comments are identified by a blue-background number. Mouse over a number to display a pop-up note with the comment.

This publication contains the CMV and the official standard. The full list of comments is available at the end of the CMV.

IEC 60384-21 has been prepared by IEC technical committee 40: Capacitors and resistors for electronic equipment. It is an International Standard.

This fourth edition cancels and replaces the third edition published in 2019. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) the document has been completely restructured to comply with the ISO/IEC Directives, Part 2 and to make it more useable; tables, figures and references have been revised accordingly; Annex X contains all cross-references of changes in clause/subclause numbers;
- b) the terms have been replaced by the letter symbols in Table 3;
- c) code of temperature coefficient and tolerance of C0G, U2J have been added in Table 4, Table 6, Table 8, Table 9, Table 11, Table 13, Table 16 and Annex B;
- d) the requirement in 5.5.2 (visual examination) has been repeated in 5.9.3, 5.10.5, 5.11.4, 5.11.4, 5.13.7, 5.14.5 and 5.15.5;
- e) the deflection D in the very robust designs has been added in 5.9.1;
- f) Annex B has been changed informative into normative;
- g) Clause C.5 (Test schedule for quality conformance inspection) has been newly added to withdraw the blank detail specification: IEC 60384-21-1.

The text of this International Standard is based on the following documents:

Draft	Report on voting
40/3119/FDIS	40/3138/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts in the IEC 60384 series, published under the general title *Fixed capacitors for use in electronic equipment*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
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- revised.

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FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 21: Sectional specification – Fixed surface mount multilayer capacitors of ceramic dielectric, Class 1

1 Scope

This part of IEC 60384 is applicable to fixed unencapsulated surface mount multilayer capacitors of ceramic dielectric with a defined temperature coefficient (dielectric Class 1), intended for use in electronic equipment. These capacitors have metallized connecting pads or soldering strips and are intended to be mounted on printed boards, or directly onto substrates for hybrid circuits.

Capacitors for electromagnetic interference suppression are not included, but are covered by IEC 60384-14.

The object of this document is to ~~prescribe~~ specify preferred ratings and characteristics and to select from IEC 60384-1:2021 the appropriate quality assessment procedures, tests and measuring methods and to give general performance requirements for this type of capacitor. ~~Test severities and requirements prescribed in detail specifications referring to this sectional specification are of equal or higher performance levels; lower performance levels are not permitted.~~ Test severities and requirements specified in detail specifications referring to this document provide specific test severities and requirements of an equal or higher performance level. Further information on the conception of generic, sectional and detail specifications can be found in the Introduction of IEC 60384-1:2021. **1**

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

~~IEC 60063, Preferred number series for resistors and capacitors~~

~~IEC 60068-1:2013, Environmental testing – Part 1: General and guidance~~

IEC 60068-2-58:2015, *Environmental testing – Part 2-58: Tests – Test Td – Test methods for solderability, resistance to dissolution of metallization and to soldering heat of surface mounting devices (SMD)*

~~IEC 60068-2-58:2015/AMD1:2017~~

IEC 60384-1:2016/2021, *Fixed capacitors for use in electronic equipment – Part 1: Generic specification*

IEC 61193-2:2007, *Quality assessment systems – Part 2: Selection and use of sampling plans for inspection of electronic components and packages*

~~ISO 3:1973, Preferred numbers – Series of preferred numbers~~

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60384-1:2021 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at <https://www.electropedia.org/>
- ISO Online browsing platform: available at <https://www.iso.org/obp>

3.1

surface mount multilayer capacitor

multilayer capacitor whose small dimensions and nature or shape of terminations make it suitable for surface mounting in hybrid circuits and on printed boards

3.2

capacitor of ceramic dielectric, Class 1

capacitor specially designed and suited for resonant circuit application where low losses and high stability of capacitance are essential or where a precisely defined temperature coefficient is required, for example for compensating temperature effects in the circuit

Note 1 to entry: The ceramic dielectric is defined by its nominal temperature coefficient (α).

3.3

subclass

<Class 1> tolerance on the temperature coefficient for a given nominal temperature coefficient;
~~the subclass is defined by the tolerance on the temperature coefficient~~

Note 1 to entry: See Table 2.

Note 2 to entry: The nominal temperature coefficient value and its tolerance refer to the temperature interval ~~of~~ from the reference temperature +20 °C or +25 °C to +85 °C, but because in practice TC curves are not strictly linear, it is necessary to define limiting capacitance deviation ($\Delta C/C$) for other temperatures (see Table 3 and Annex B).

3.4

~~category~~ **temperature range**

ambient temperature range for which the capacitor has been designed to operate continuously

Note 1 to entry: This is given by the lower and upper category temperature. (see Table 3 and Annex B).

3.5

rated temperature

T_R

maximum ambient temperature at which the rated voltage ~~may~~ can be continuously applied

3.6

rated voltage

U_R

maximum DC voltage that ~~may~~ can be applied continuously to a capacitor at any temperature between the lower category temperature and the rated temperature

Note 1 to entry: The maximum DC voltage is the sum of the DC voltage and peak AC voltage or peak pulse voltage applied to the capacitor.

3.7

category voltage

U_C

maximum voltage that can be applied continuously to a capacitor at its upper category temperature

4 Preferred ratings and characteristics

4.1 Preferred characteristics

Preferred climatic categories only shall be given in the preferred characteristics.

The capacitors covered by this document are classified into climatic categories in accordance with the general rules given in IEC 60068-1:2013, Annex A.

For reference temperature 20 °C or 25 °C **2**, the lower and upper category temperatures and the duration of the damp heat, steady state test shall be chosen from the following:

- lower category temperature: –55 °C, –40 °C, –25 °C, –10 °C and +10 °C;
- upper category temperature: +70 °C, +85 °C, +100 °C, +125 °C ~~and +150 °C~~;
- duration of the damp heat, steady state test (40 °C, 93 % RH): 4, 10, 21 and 56 days.

The severities of the cold and dry heat tests are the lower and upper category temperatures respectively.

NOTE The resistance to humidity resulting from the above climatic category is for the capacitors in their unmounted state. The climatic performance of the capacitors after mounting is greatly influenced by the mounting substrate, the mounting method (see 5.4) and the final coating.

4.2 Preferred values of ratings

4.2.1 Rated temperature (T_R)

For capacitors covered by this document, the rated temperature is equal to the upper category temperature, unless the upper category temperature exceeds 125 °C.

4.2.2 Rated voltage (U_R)

The preferred values of the rated voltage are the values of the R5 series of ISO 3. If other values are needed, they shall be chosen from the R10 series.

The sum of the DC voltage and the peak AC voltage or the peak-to-peak AC voltage, whichever is the greater, applied to the capacitor shall not exceed the rated voltage.

4.2.3 Category voltage (U_C)

When the rated temperature is defined as the upper category temperature, the category voltage is equal to the rated voltage as defined in IEC 60384-1:2016/2021, 3.5. If the upper category temperature exceeds 125 °C, or the rated voltages exceed 500 V, the category voltage shall be given in the detail specification.

4.2.4 Preferred values of nominal capacitance and associated tolerance values

4.2.4.1 Preferred values of nominal capacitance

Nominal capacitance values ~~shall~~ should be taken from ~~the number series of IEC 60063~~; the E6, E12 and E24 series ~~are preferred~~ given in IEC 60063.

4.2.4.2 Preferred tolerances on nominal capacitance

See Table 1.

Table 1 – Preferred tolerances on nominal capacitance

Preferred series	Tolerance			
	$C_N \geq 10 \text{ pF}$	Letter code	$C_N < 10 \text{ pF}$	Letter code
E6	$\pm 20 \%$	M	$\pm 2 \text{ pF}$	G
E12	$\pm 10 \%$	K	$\pm 1 \text{ pF}$	F
E24	$\pm 5 \%$	J	$\pm 0,5 \text{ pF}$	D
	$\pm 2 \%$	G	$\pm 0,25 \text{ pF}$	C
	$\pm 1 \%$	F	$\pm 0,1 \text{ pF}$	B

4.2.5 Temperature coefficient (α)

4.2.5.1 Nominal temperature coefficient and tolerance (for reference temperature 20 °C)

Table 2 shows the ~~preferred~~ nominal temperature coefficients for the reference temperature 20 °C, the associated tolerances, expressed in parts per million per Kelvin ($10^{-6}/\text{K}$), and the corresponding subclasses and letter codes. The temperature coefficients, tolerances and letter codes for the reference temperature 25 °C are given in Annex B. **3**

The detail specification shall specify for each temperature coefficient the minimum value of capacitance for which the given tolerance of temperature coefficient can be verified, considering the accuracy of the methods of capacitance measurement specified.

For values of capacitance lower than this minimum value:

- the detail specification shall specify a multiplying factor for the tolerance on α , as well as the permissible changes of capacitance at the lower and upper category temperature;
- special methods of measurement ~~may~~ can be necessary and, if required, shall be stated in the detail specification.

Table 2 – Nominal temperature coefficient and tolerance (for reference temperature 20 °C)

Nominal temperature coefficient ($10^{-6}/\text{K}$)	Tolerance on temperature coefficient ($10^{-6}/\text{K}$)	Subclass	Letter code for	
			α	Tolerance
+100	± 30	1B	A	G
0	± 30	1B	C	G
-33	± 30	1B	H	G
-75	± 30	1B	L	G
-150	± 30	1B	P	G
-220	± 30	1B	R	G
-330	± 60	1B	S	H
-470	± 60	1B	T	H
-750	± 120	1B	U	J
-1 000	± 250	1F	Q	K
-1 500	± 250	1F	V	K
$+140 \geq \alpha \geq -1\,000$	^a	1C	SL	-

~~NOTE 1 Preferred temperature coefficients values (α) are underlined.~~

~~NOTE 2~~ The nominal temperature coefficients and their tolerances are defined using the capacitance change between the temperatures 20 °C and 85 °C.

~~NOTE 3~~ A capacitor with a temperature coefficient $0 \times 10^{-6}/\text{K}$ and a tolerance on temperature coefficient of $\pm 30 \times 10^{-6}/\text{K}$ is designated as a CG capacitor (subclass 1B).

^a This temperature coefficient value is not subject to inspection since no limits for relative capacitance variation are specified in Table 3.

~~NOTE See Annex B for the reference temperature of 25 °C as an informative guidance.~~

4.2.5.2 Permissible relative variation of capacitance

Table 3 shows for each combination of temperature coefficient and tolerance the permissible relative variation of capacitance expressed in parts per thousand at both the upper and lower category temperatures. Temperature coefficients and tolerances are expressed in parts per million per Kelvin ($10^{-6}/\text{K}$). In case of reference temperature 25 °C, see Table B.1 for an explanation of the permissible relative variation of capacitance.

Table 3 – Combination of temperature coefficient and tolerance

		Permissible relative variation in capacitance in parts per 1 000 between 20 °C and a given temperature							
		Lower category temperature				Upper category temperature			
α $10^{-6}/\text{K}$	Tolerance $10^{-6}/\text{K}$	-55 °C	-40 °C	-25 °C	-10 °C	+70 °C	+85 °C	+100 °C	+125 °C
+100	± 30 (G)	-9,75/ -3,71	-7,80/ -2,96	-5,85/ -2,22	-3,90/ -1,48	3,50/ 6,50	4,55/ 8,45	5,60/ 10,4	7,35/ 13,7
0	± 30 (G)	-2,25/ 5,45	-1,80/ 4,36	-1,35/ 3,27	-0,90/ 2,18	-1,50/ 1,50	-1,95/ 1,95	-2,40/ 2,40	-3,15/ 3,15
-33	± 30 (G)	0,225/ 8,47	0,180/ 6,77	0,135/ 5,08	0,090/ 3,39	-3,15/ -0,15	-4,10/ -0,195	-5,04/ -0,240	-6,62/ -0,32
-75	± 30 (G)	3,38/ 12,3	2,70/ 9,85	2,03/ 7,39	1,35/ 4,92	-5,25/ -2,25	-6,83/ -2,93	-8,40/ -3,60	-11,0/ -4,73
-150	± 30 (G)	9,00/ 19,2	7,20/ 15,3	5,40/ 11,5	3,60/ 7,67	-9,00/ -6,0	-11,7/ -7,80	-14,4/ -9,60	-18,9/ -12,6
-220	± 30 (G)	14,3/ 25,6	11,4/ 20,46	8,55/ 15,3	5,70/ 10,2	-12,5/ -9,50	-16,2/ -12,4	-20,0/ -15,2	-26,3/ -20,0
-330	± 60 (H)	20,3/ 38,4	16,2/ 30,7	12,2/ 23,0	8,10/ 15,4	-19,5/ -13,5	-25,4/ -17,6	-31,2/ -21,6	-41,0/ -28,4
-470	± 60 (H)	30,8/ 51,2	24,6/ 41,0	18,5/ 30,7	12,3/ 20,5	-26,5/ -20,5	-34,5/ -26,7	-42,4/ -32,8	-55,7/ -43,1
-750	± 120 (J)	47,3/ 82,3	37,8/ 65,8	28,4/ 49,4	18,9/ 32,9	-43,5/ -31,5	-56,6/ -41,0	-69,6/ -50,4	-91,4/ -66,2
-1 000	± 250 (K)	56,3/ 117	45,0/ 93,7	33,8/ 70,2	22,5/ 46,8	-62,5/ -37,5	-81,3/ -48,8	-100/ -60,0	-131/ -78,8
-1 500	± 250 (K)	93,8/ 163	75,0/ 130	56,3/ 97,7	37,5/ 65,1	-87,5/ -62,5	-114/ -81,3	-140/ -100	-184/ -131

When the upper category temperature is above 125 °C, the limits shall be given in the detail specification.

~~NOTE 1 Preferred temperature coefficient values (α) are underlined.~~

~~NOTE 2 The temperature coefficient limits at the temperature range from 20 °C to the upper category temperature are calculated by the nominal temperature coefficients and their tolerances (see formula a) of NOTE 3).~~

~~The temperature coefficient limits at the temperature range from 20 °C to 55 °C are calculated by using the formulas b) and c) of NOTE 3.~~

~~NOTE 3 The capacitance deviations at the lower category temperature are obtained by using following formulas:~~

~~a) upper and lower permissible relative variation in capacitance under upper category temperature:~~

$$\Delta C/C (10^{-3}) = (\text{nominal temperature coefficient} \pm \text{tolerance on temperature coefficient}) \times (\text{upper category temperature} - 20) / 1\,000$$

~~b) lower permissible relative variation in capacitance under lower category temperature:~~

$$\Delta C/C (10^{-3}) = (\text{nominal temperature coefficient} \pm \text{tolerance on temperature coefficient}) \times (\text{lower category temperature} - 20) / 1\,000$$

~~c) upper permissible relative variation in capacitance under lower category temperature:~~

$$\Delta C/C (10^{-3}) = [(-36) - (1,22 \times \text{tolerance on temperature coefficient}) + (0,22 \times \text{nominal temperature coefficient}) + \text{nominal temperature coefficient}] \times (\text{lower category temperature} - 20) / 1\,000$$

~~where tolerance on temperature coefficient* is an absolute value.~~

Formulas for calculation of the permissible relative variation in capacitance:

Permissible relative variation in the temperature range from 20 °C to the upper category temperature:

$$\Delta C/C (10^{-3}) = (\alpha \pm |\delta|) \times (UCT - 20) / 1\,000 \quad (1)$$

Permissible relative variation in the temperature range from 20 °C to the lower category temperature:

a) lower permissible relative variation in capacitance from 20 °C to lower category temperature:

$$\Delta C/C (10^{-3}) = (\alpha \pm |\delta|) \times (LCT - 20) / 1\,000 \quad (2)$$

b) upper permissible relative variation in capacitance from 20 °C to lower category temperature:

$$\Delta C/C (10^{-3}) = [(-36) - (1,22 \times |\delta|) + (0,22 \times \alpha) + \alpha] \times (LCT - 20) / 1\,000 \quad (3)$$

α Temperature coefficient

δ Tolerance of α

LCT Lower category temperature

UCT Upper category temperature

4.2.6 Dimensions

Suggested rules for the specification and coding of dimensions are given in Annex A.

Specific dimensions shall be given in the detail specification.

5 Test and measurement procedures

5.1 General

This Clause 5 supplements the information given in IEC 60384-1:2016/2021, Clause 5 to Clause 10.

5.2 Preliminary drying

See IEC 60384-1:~~2016~~2021, 5.3.

5.3 Measuring conditions

See IEC 60384-1:~~2016~~2021, 5.2.1.

5.4 Mounting

See IEC 60384-1:~~2016~~2021, 5.5.

5.5 Visual examination and check of dimensions

5.5.1 General

See IEC 60384-1:~~2016~~2021, 7.1, with the details of 5.5.2 and 5.5.3.

5.5.2 Visual examination

A visual examination shall be carried out with suitable equipment with approximately 10× magnification and lighting appropriate to the specimen under test and the quality level required. *In case the specimen are very small components, the visual examination may be carried out with higher magnification.*

The operator should have available facilities for incident or transmitted illumination as well as an appropriate measuring facility.

5.5.3 Requirements

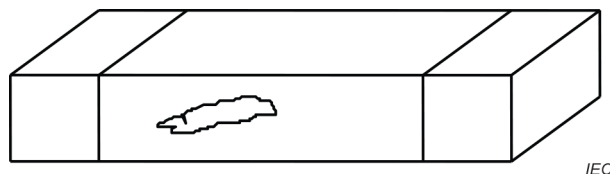
5.5.3.1 General

Quantitative values for the requirements below may be given in the detail or in the manufacturer's specification.

5.5.3.2 Requirements for the ceramic

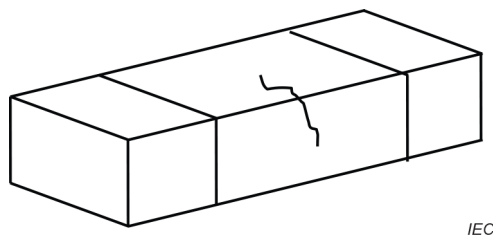
Requirements for the ceramic are as follows:

- a) Be free of cracks or fissures, except small damages on the surface, that do not deteriorate the performance of the capacitor (examples: see Figure 1 and Figure 2).



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Figure 1 – Fault: crack or fissure



NOTE Crack or fissure on one side or extending from one face to another over a corner.

Figure 2 – Fault: crack or fissure

- b) Not exhibit visible separation or delamination between the layers of the capacitor (see Figure 3).

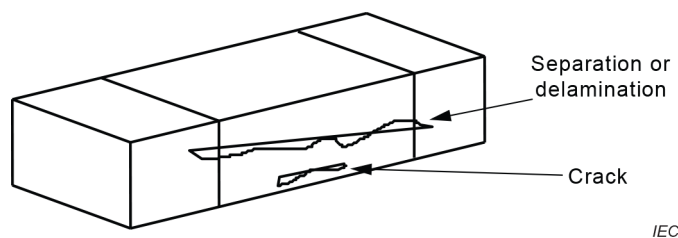


Figure 3 – Separation or delamination

- c) Not exhibit exposed electrodes between the two terminations (see Figure 4).

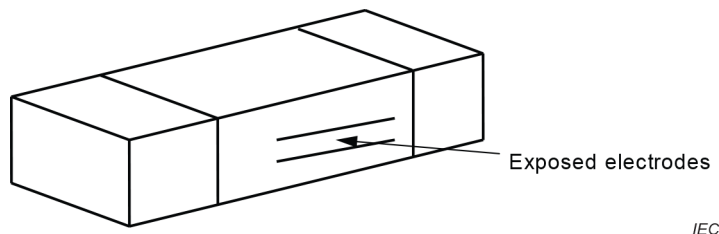


Figure 4 – Exposed electrodes

- d) The ceramic body shall be free of any conducting smears (metallization, tinning, etc.) on a central zone between two adjacent terminations which is equal to the minimum distance between those (Annex A, dimension L_4).

5.5.3.3 Requirements for the metallization

Requirements for the metallization are as follows:

- Not exhibit any visible detachment of the metallized terminations and not exhibit any exposed electrodes (see Figure 4).
- The principal faces (see Figure 5) are those noted A, B and C.

In the case of capacitors of square section, the faces D and E are also considered principal.

The maximum area of gaps in metallization on each principal face shall not be greater than 15 % of the area of that face; these gaps shall not be concentrated in the same area. The gaps in metallization shall not affect the two principal edges of each extremity of the block (or four edges for square section capacitors). Dissolution of the end face plating (leaching) shall not exceed 25 % of the length of the edge concerned.

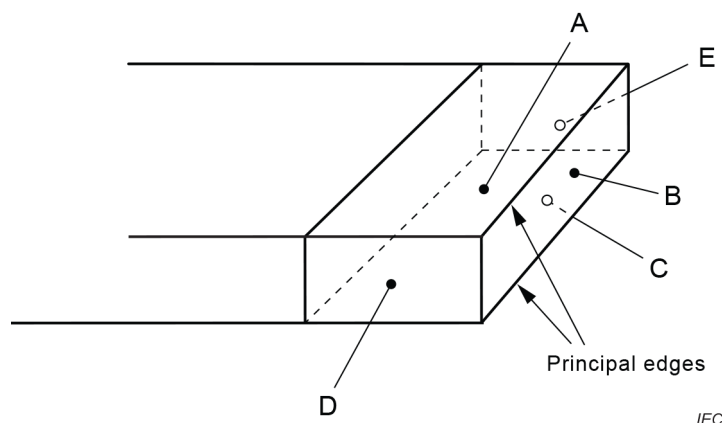


Figure 5 – Principal faces

5.6 Electrical tests

5.6.1 Capacitance

5.6.1.1 General

See IEC 60384-1:2016/2021, 6.3, with the details of 5.6.1.2 and 5.6.1.3.

5.6.1.2 Measuring conditions

Unless otherwise specified in the detail specification,

- measuring voltage: ≤ 5 V RMS,
- frequency: $C_N \leq 1\,000$ pF 1 MHz or 100 kHz (referee frequency 1 MHz);
 $C_N > 1\,000$ pF 1 kHz or 100 kHz (referee frequency 1 kHz).

5.6.1.3 Requirements

The capacitance value as measured in the unmounted state, shall correspond to the rated value taking into account the specified tolerance.

The capacitance as measured in the mounted state in accordance with Group 3 is for reference purposes only in further tests.

5.6.2 Tangent of loss angle ($\tan \delta$)

5.6.2.1 General

See IEC 60384-1:2016/2021, 6.4, with the details of 5.6.2.2 and 5.6.2.3.

5.6.2.2 Measuring conditions

The measuring conditions are the same as those of 5.6.1. The inaccuracy of the measuring equipment shall not exceed 3×10^{-4} .

5.6.2.3 Requirements

The tangent of loss angle as measured in the unmounted state shall not exceed the limit given in Table 4.

Table 4 – Tangent of loss angle limits

Nominal capacitance pF	Tangent of loss angle ($\tan \delta$) $\times 10^{-4}$		
	$+100 \geq \alpha > -750$ and SL (1C) C0G	$-750 \geq \alpha > -1\ 500$ U2J	$\alpha = -1\ 500$
$C_N \geq 50$	15	20	30
$5 \leq C_N < 50$	$1,5 \left(\frac{150}{C_N} + 7 \right)$	$2 \left(\frac{150}{C_N} + 7 \right)$	$3 \left(\frac{150}{C_N} + 7 \right)$
$C_N < 5$	When the measurement is required the detail specification shall specify the limit.		

The tangent of loss angle as measured in the mounted state in accordance with Group 3 is for reference purpose only in further tests.

5.6.3 Insulation resistance

5.6.3.1 General

See IEC 60384-1:2016/2021, 6.1, with the details of 5.6.3.2 to 5.6.3.4.

5.6.3.2 Preparation for test

Prior to the test, capacitors shall be carefully cleaned to remove any contamination.

Care shall be taken to maintain cleanliness in the test chambers and during post-test measurements. Before the measurement, the capacitors shall be fully discharged. The insulation resistance shall be measured between the terminations.

5.6.3.3 Measuring conditions

See IEC 60384-1:2016/2021, 6.1.2, with the following details.

The measuring voltage may be of any value not greater than U_R , the referee voltage being U_R , for a capacitor with a rated voltage below or equal to 1 kV. For $U_R > 1$ kV the referee voltage shall be 1 kV.

The insulation resistance (R_i) shall be measured after the voltage has been applied for (60 ± 5) s.

For lot-by-lot testing (Group A) the test may be terminated in a shorter time, if the required value of insulation resistance is reached.

The product of the internal resistance of the voltage source and the nominal capacitance of the capacitor shall not exceed 1 s, unless otherwise ~~prescribed~~ specified in the detail specification.

The charge current shall not exceed 0,05 A. For capacitors with rated voltages of 1 kV and above, a lower limit (value) may be given in the detail specification.

5.6.3.4 Requirements

The insulation resistance shall meet the following requirements.

$C_N \leq 10$ nF	$R_i \geq 10\ 000$ M Ω
$C_N > 10$ nF	$R_i \times C_N \geq 100$ s

5.6.4 Voltage proof

5.6.4.1 General

See IEC 60384-1:20162021, 6.2, with the details of 5.6.4.2 to 5.6.4.4.

5.6.4.2 Test conditions

The product of R_1 and the nominal capacitance C_X shall be smaller than or equal to 1 s.

NOTE R_1 is a charging resistor that includes the internal resistance of the voltage source. More information can be found in IEC 60384-1:20162021, 6.2.2.

The charge current shall not exceed 0,05 A.

For capacitors with rated voltages of 1 kV and above, a lower charge current limit value may be given in the detail specification. To protect the capacitors against flashover, the test may be performed in a suitable insulating medium.

5.6.4.3 Test voltages

The test voltages in accordance with Table 5 shall be applied between the measuring points of 5.6.3 and Table 3 in IEC 60384-1:20162021, for a period of 1 min for qualification approval testing and for a period of 1 s for the lot-by-lot quality conformance testing.

Table 5 – Test voltages

Rated voltage V	Test voltage V
$U_R \leq 100$	$2,5 U_R$
$100 < U_R \leq 200$	$1,5 U_R + 100$
$200 < U_R \leq 500$	$1,3 U_R + 100$
$500 < U_R < 1\,000$	$1,3 U_R$
$U_R \geq 1\,000$	$1,2 U_R$

5.6.4.4 Requirement

There shall be no breakdown or flashover during the test.

5.7 Temperature coefficient (α) and temperature~~-cycle~~ cyclic drift

5.7.1 General

See IEC 60384-1:20162021, 6.8.3.3, with the details of 5.7.2 to 5.7.4.

5.7.2 Preliminary drying

The capacitors shall be dried in accordance with 5.2 for 16 h to 24 h.

5.7.3 Measuring conditions

See IEC 60384-1:20162021, 6.8.1.2 and 6.8.1.3, with the following details.

The capacitors shall be measured in the unmounted state.

5.7.4 Requirements

The capacitance deviation at upper and lower category temperature (and at such other temperatures as may be specified in the detail specification) shall not exceed the limits given in Table 3.

The temperature cyclic drift shall not exceed the limits given in Table 6.

Table 6 – Temperature cyclic drift limits

α rated in $10^{-6}/K$	Requirements ^a
$+100 \geq \alpha > -150$ C0G	0,3 % or 0,05 pF
$-150 \geq \alpha > -1\ 500$ and SL (1C) U2J	1 % or 0,05 pF
$\alpha = -1\ 500$	2 % or 0,05 pF
^a Whichever is the greater.	

5.8 Shear test

See IEC 60384-1:20162021, 7.7.

A force shall be selected from 1 N, 2 N, 5 N or 10 N and specified in the detail specification.

5.9 Substrate bending test

5.9.1 General

See IEC 60384-1:20162021, 7.8.

Unless otherwise specified in the detail specification,

- the deflection D shall be selected from 1 mm, 2 mm or 3 mm, higher deflection values may be given in the detail specification in case of very robust designs.
- the number of bends shall be 1 time,
- the radius of the bending tool shall be 5 mm,
When the deflection D is 2 mm or less, the radius may be 230 mm.
- the duration in the bent state shall be 5 s.

For 1005 M or smaller size, the thickness of substrate should be 0,8 mm.

5.9.2 Initial measurement

The capacitance shall be measured as specified in 5.6.1 and in the detail specification.

5.9.3 Final inspection

The capacitors shall be visually examined and there shall be no visible damage.

See 5.5.2.

The change of capacitance with board in bent position shall not exceed 5 %.

5.10 Resistance to soldering heat

5.10.1 General

See IEC 60068-2-58 with the details of 5.10.2 to 5.10.5.

5.10.2 Initial measurement

The capacitance shall be measured in accordance with 5.6.1.

5.10.3 Test conditions

5.10.3.1 Solder bath method (applicable to 1608 M, 2012 M and 3216 M)

~~NOTE~~—See Table A.1 for explanation of the size code.

See IEC 60068-2-58, Test Td₂, Method 1, with the following details, if not otherwise specified in the detail specification:

The specimen shall be preheated to a temperature of 110 °C to 140 °C and maintained for 30 s to 60 s.

Solder alloy:	Sn-Pb or Sn-Ag-Cu
Temperature:	260 °C ± 5 °C
Duration of immersion:	10 s ± 1 s
Depth of immersion:	10 mm
Number of immersions:	1

5.10.3.2 Infrared and forced gas convection soldering system

See IEC 60068-2-58, Test Td₂, Method 2, with the following details:

- a) the solder paste shall be applied to the test substrate;
- b) the thickness of solder deposit shall be specified in the detail specification;
- c) the terminations of the specimen shall be placed on the solder paste;
- d) solder alloy: Sn-Pb;

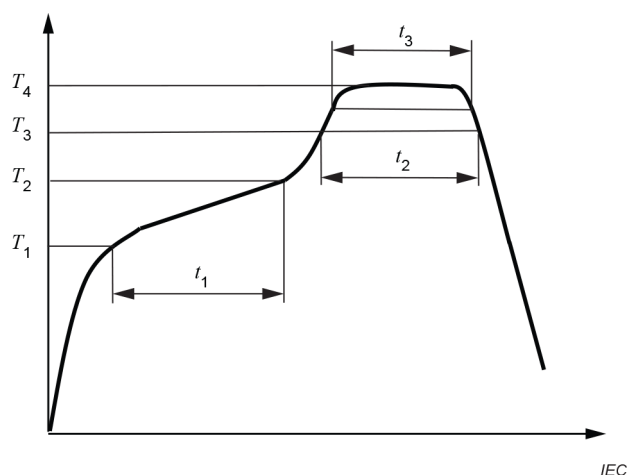
unless otherwise specified in the detail specification, the specimen and test substrate shall be preheated to a temperature of (150 ± 10) °C and maintained for 60 s to 120 s in infrared and forced gas convection soldering system;

the temperature of the reflow system shall be quickly raised until the specimen has reached (235 ± 5) °C and maintained at this temperature for (10 ± 1) s;
- e) solder alloy: Sn-Ag-Cu;

unless otherwise specified in the detail specification, the reflow temperature profile shall be selected from Table 7 and Figure 6;

Table 7 – Reflow temperature profiles for Sn-Ag-Cu alloy

Alloy composition		T_1 °C	T_2 °C	t_1 s	T_3 °C	t_2 s	T_4 °C	t_3 s
Lead-free solder (Sn-Ag-Cu)	Test 1	150 ± 5	180 ± 5	120 ± 5	220	60 to 90	250	20 to 40 at $T_4 - 5 \text{ °C}$
	Test 2	~~150 ± 5~~	~~180 ± 5~~	~~120 ± 5~~	~~220~~	~~≤ 60~~	~~255~~	~~≤ 20 at $T_4 - 10 \text{ °C}$~~

**Figure 6 – Reflow temperature profile**

- f) number of each test: 1, unless otherwise specified in the detail specification;
g) the temperature profile of d) or e) shall be specified in the detail specification.

5.10.4 Recovery

The capacitors shall recover for 6 h to 24 h.

The flux residues shall be removed with a suitable solvent.

5.10.5 Final inspection, measurements and requirements

After recovery, the capacitors shall be visually examined and measured and shall meet the following requirements.

Under normal lighting and approximately 10× magnification, there shall be no signs of damage such as cracks. See 5.5.2.

Dissolution of the end face plating (leaching) shall not exceed 25 % of the length of the edge concerned. The detail specification may ~~prescribe~~ specify further details.

The capacitance shall be measured in accordance with 5.6.1 and the change shall not exceed the values in Table 8.

Table 8 – Maximum capacitance change

α rated in $10^{-6}/K$	Requirements ^a
$+100 \geq \alpha \geq -750$ C0G and U2J	0,5 % or 0,5 pF
$-750 > \alpha \geq -1\ 500$ and SL (1C)	1 % or 1 pF
^a Whichever is the greater.	

5.11 Solderability

5.11.1 General

See IEC 60068-2-58 with the details of 5.11.2 to 5.11.4.

5.11.2 Test conditions

5.11.2.1 Solder bath method (applicable to 1608 M, 2012 M and 3216 M)

~~NOTE~~—See Table A.1 for explanation of the size code.

See IEC 60068-2-58, Test Td₁, Method 1, with the following details, if not otherwise specified in the detail specification:

The specimen shall be preheated to a temperature of 80 °C to 140 °C and maintained for 30 s to 60 s.

Solder alloy:	Sn-Pb	Sn-Ag-Cu
Temperature:	(235 ± 5) °C	(245 ± 5) °C
Duration of immersion:	(2 ± 0,2) s	(3 ± 0,3) s
Depth of immersion:	10 mm	10 mm
Number of immersions:	1	1

5.11.2.2 Infrared and forced gas convection soldering system

See IEC 60068-2-58, Test Td₁, Method 2, with the following details:

- the solder paste shall be applied to the test substrate;
- the thickness of solder deposit shall be specified in the detail specification;
- the terminations of the specimen shall be placed on the solder paste;
- solder alloy: Sn-Pb;

unless otherwise specified in the detail specification, the specimen and test substrate shall be preheated to a temperature of (150 ± 10) °C and maintained for 60 s to 120 s in the infrared and forced gas convection soldering system;

the temperature of the reflow system shall be quickly raised until the specimen has reached (215 ± 3) °C and maintained at this temperature for (10 ± 1) s;
- solder alloy: Sn-Ag-Cu;

unless otherwise specified in the detail specification, the specimen and test substrate shall be preheated to a temperature of (150 ± 5) °C to (180 ± 5) °C for 60 s to 120 s in the infrared and forced gas convection soldering system;

the temperature of the reflow system shall be quickly raised until the specimen has reached (235 ± 3) °C. The time above 225 °C shall be (20 ± 5) s;
- the temperature profile of d) or e) shall be specified in the detail specification.

5.11.3 Recovery

The flux residues shall be removed with a suitable solvent.

5.11.4 Final inspection, measurements and requirements

The capacitors shall be visually examined under normal lighting and approximately 10× magnification. There shall be no signs of damage. See 5.5.2.

Both end face and the contact areas shall be covered with a smooth and bright solder coating with no more than a small number of scattered imperfections such as pinholes or unwetted or de-wetted areas. These imperfections shall not be concentrated in one area.

The detail specification may ~~prescribe~~ specify further requirements.

5.12 Rapid change of temperature

5.12.1 General

This test shall be applied only to capacitors for which the category temperature is greater 110 °C.

See IEC 60384-1:20162021, 8.1, with the details of 5.12.2 to 5.12.5.

The capacitors shall be mounted in accordance with 5.4.

5.12.2 Initial measurement

The capacitance shall be measured in accordance with 5.6.1.

5.12.3 Number of cycles

The number of cycles: 5.

Duration of exposure at the temperature limits: 30 min.

5.12.4 Recovery

The capacitors shall recover for 6 h to 24 h.

5.12.5 Final inspection, measurements and requirements

The capacitors shall be visually examined. There shall be no visible damage. See 5.5.2.

The capacitance shall be measured in accordance with 5.6.1 and the change shall not exceed the value in Table 9.

Table 9 – Maximum capacitance change

α rated in $10^{-6}/K$	Requirements ^a
$+100 \geq \alpha \geq -750$ C0G and U2J	1 % or 1 pF
$-750 > \alpha \geq -1\,500$ and SL (1C)	2 % or 1 pF
^a Whichever is the greater.	

5.13 Climatic sequence

5.13.1 General

See IEC 60384-1:20162021, 8.2, with the details of 5.13.2 to 5.13.7.

5.13.2 Initial measurement

The capacitance shall be measured in accordance with 5.6.1.

5.13.3 Dry heat

See IEC 60384-1:20162021, 8.2.3.

5.13.4 Damp heat, cyclic, Test Db, first cycle

See IEC 60384-1:20162021, 8.2.4.

5.13.5 Cold

See IEC 60384-1:20162021, 8.2.5, with the following details.

The capacitors shall be visually examined. There shall be no visible damage.

5.13.6 Damp heat, cyclic, Test Db, remaining cycles

5.13.6.1 General

See IEC 60384-1:20162021, 8.2.7, with the details of 5.13.6.2 and 5.13.6.3.

5.13.6.2 Test conditions

No voltage applied.

The remaining cycles shall be tested in accordance with Table 10.

Table 10 – Number of damp heat cycles

Category	No. of cycles of 24 h
- / – / 56	5
- / – / 21	1
- / – / 10	1
- / – / 04	0

5.13.6.3 Recovery

The capacitors shall recover for 6 h to 24 h.

5.13.7 Final inspection, measurements and requirements

The capacitors shall be visually examined. There shall be no visible damage. See 5.5.2.

The capacitors shall be measured and shall meet the requirements in Table 11.

Table 11 – Final inspection, measurements and requirements

Measurement	Measurement and conditions	α rated and (Subclass)	Requirements
Capacitance	5.6.1	+100 $\geq \alpha \geq$ -750 (1B) C0G and U2J	Capacitance change $\leq 2\%$ or 1 pF ^a
		-750 $> \alpha \geq$ -1 500 (1F) SL (1C)	Capacitance change $\leq 3\%$ or 1 pF ^a
Tangent of loss angle	5.6.2	All α s and subclasses	$\leq 2\times$ value in the table of 5.6.2
Insulation resistance	5.6.3	All α s and subclasses	$R_i \geq 2\,500\text{ M}\Omega$ or $R_i \times C_N \geq 25\text{ s}$ ^b
NOTE See 4.2.5 for an explanation of the subclass codes. ^a Whichever is the greater. ^b Whichever is the lower.			

5.14 Damp heat, steady state

5.14.1 General

See IEC 60384-1:2016/2021, 8.3, with the details of 5.14.2 to 5.14.5.

The capacitors shall be mounted in accordance with 5.4.

5.14.2 Initial measurement

The capacitance shall be measured in accordance with 5.6.1.

5.14.3 Test conditions

No voltage shall be applied, unless otherwise specified in the detail specification.

The severity of the test should be selected from the test conditions as shown in Table 12 and be specified in the detail specification.

The duration time should be selected in accordance with 4.1 and shall be specified in the detail specification.

Table 12 – Test conditions for damp heat, steady state

Severity	Temperature °C	Relative humidity %
1	+85 $\pm$ 2	85 $\pm$ 3
2	+60 $\pm$ 2	93 $\pm$ 3
3	+40 $\pm$ 2	93 $\pm$ 3

When the application of voltage is ~~prescribed~~ specified, U_R shall be applied to one half of the lot and no voltage shall be applied to the other half of the lot.

Within 15 min after removal from the damp heat test, the voltage proof test in accordance with 5.6.4 shall be carried out, but with the rated voltage applied.

For safety reasons, different conditions for the application of voltage to capacitors with rated voltages of 1 kV or above may be given in the detail specification.

5.14.4 Recovery

The capacitors shall recover for 6 h to 24 h.

5.14.5 Final inspection, measurements and requirements

The capacitors shall be visually examined. There shall be no visible damage. See 5.5.2.

The capacitors shall be measured and shall meet the requirements in Table 13.

Table 13 – Final inspection, measurements and requirements

Measurement	Measurement and conditions	α rated and (Subclass)	Requirements
Capacitance	5.6.1	+100 $\geq \alpha \geq$ -750 (1B) C0G and U2J	Capacitance change $\leq 2\%$ or 1 pF ^a
		-750 $> \alpha \geq$ -1 500 (1F) SL (1C)	Capacitance change $\leq 3\%$ or 1 pF ^a
Tangent of loss angle	5.6.2	All α s and subclasses	$\leq 2\times$ value in the table of 5.6.2
Insulation resistance	5.6.3	All α s and subclasses	$R_i \geq 2\,500\text{ M}\Omega$ or $R_i \times C_N \geq 25\text{ s}^b$
NOTE See 4.2.5 for an explanation of the subclass codes. ^a Whichever is the greater. ^b Whichever is the lower.			

5.15 Endurance

5.15.1 General

See IEC 60384-1:2016/2021, 8.5, with the details of 5.15.2 to 5.15.5.

The capacitors shall be mounted in accordance with 5.4.

5.15.2 Initial measurement

The capacitance shall be measured in accordance with 5.6.1.

5.15.3 Test conditions

If the category voltage is equal to the rated voltage, the capacitors shall be tested as in Table 14.

Table 14 – Endurance test conditions ($U_C = U_R$)

U_R	$U_R \leq 200$	$200 < U_R \leq 500$	$U_R > 500$
Temperature	Upper category temperature		
Voltage (DC)	1,5 U_R	1,3 U_R	1,2 U_R
Duration	1 000 h	1 500 h	2 000 h

If the category voltage is not equal to the rated voltage, the capacitors shall be tested as in Table 15.

Table 15 – Endurance test conditions ($U_C \neq U_R$)

U_R	$U_R \leq 200$		$200 < U_R \leq 500$		$U_R > 500$	
Temperature	T_R	T_B	T_R	T_B	T_R	T_B
Voltage (DC)	1,5 U_R	1,5 U_C	1,3 U_R	1,3 U_C	1,2 U_R	1,2 U_C
Duration	1 000 h		1 500 h		2 000 h	
Sample	Divided into two parts		Divided into two parts		Divided into two parts	
T_R = Rated temperature.						
T_B = Upper category temperatures > 85 °C, such as 100 °C, 125 °C and 150 °C.						

5.15.4 Recovery

The capacitors shall recover for 6 h to 24 h.

5.15.5 Final inspection, measurements and requirements

The capacitors shall be visually examined. There shall be no visible damage. See 5.5.2.

The capacitors shall be measured and shall meet the requirements in Table 16.

Table 16 – Final inspection, measurements and requirements

Measurement	Measurement and conditions	α rated and (Subclass)	Requirements
Capacitance	5.6.1	$+100 \geq \alpha \geq -750$ (1B) C0G and U2J	Capacitance change $\leq 2 \%$ or 1 pF^a
		$-750 > \alpha \geq -1\,500$ (1F) SL (1C)	Capacitance change $\leq 3 \%$ or 1 pF^a
Tangent of loss angle	5.6.2	All α s and subclasses	$\leq 2 \times$ value in the table of 5.6.2.
Insulation resistance	5.6.3	All α s and subclasses	$R_i \geq 4\,000 \text{ M}\Omega$ or $R_i \times C_N \geq 40 \text{ s}^b$
NOTE See 4.2.5 for an explanation of the subclass codes.			
^a Whichever is the greater.			
^b Whichever is the lower.			

5.16 Robustness of terminations (only for capacitors with strip termination)

5.16.1 General

See IEC 60384-1:2016/2021, 7.3, with the details of 5.16.2 and 5.16.3.

5.16.2 Test conditions

Unless otherwise specified in the detail specification, the conditions of the tests are as follows:

- Test U_{a1} : force: 2,5 N;
- Test U_b , Method 1: force: 2,5 N;

- number of bends: 1.

5.16.3 Final inspection and requirements

The capacitors shall be visually examined. There shall be no visible damage.

5.17 Component solvent resistance (if required)

See IEC 60384-1:20162021, 9.4.

5.18 Solvent resistance of the marking (if required)

See IEC 60384-1:20162021, 9.5.

5.19 Accelerated damp heat, steady state (if required)

5.19.1 General

See IEC 60384-1:20162021, 8.9, with the details of 5.19.2 to 5.19.5.

The capacitors shall be mounted in accordance with 5.4 and IEC 60384-1:20162021, 8.9.1.

Half the capacitors shall be connected in series with resistors of 100 k Ω , with a relative tolerance of ± 10 %, and half in series with resistors of 6,8 k Ω , with a relative tolerance of ± 10 %.

5.19.2 Initial measurement

The capacitors shall be measured for insulation resistance with a voltage of $1,5 \text{ V} \pm 0,1 \text{ V}$ applied across the capacitor and resistor in series.

The insulation resistance, including the series resistor, shall meet the requirements given in Table 17.

Table 17 – Initial requirements

Measurement	Measuring conditions	Requirements	
Insulation resistance	$(1,5 \pm 0,1) \text{ V}$	Connected to 100 k Ω resistors	$C_N \leq 10 \text{ nF}$: $R_i \geq 10\,000 \text{ M}\Omega$ $C_N > 10 \text{ nF}$: $(R_i - 100 \text{ k}\Omega) \times C_N \geq 100 \text{ s}$
		Connected to 6,8 k Ω resistors	$C_N \leq 10 \text{ nF}$: $R_i \geq 10\,000 \text{ M}\Omega$ $C_N > 10 \text{ nF}$: $(R_i - 6,8 \text{ k}\Omega) \times C_N \geq 100 \text{ s}$

5.19.3 Conditioning

The capacitors with associated resistors shall be subjected to conditioning at $(85 \pm 2) ^\circ\text{C}$, $(85 \pm 3) \%$ relative humidity for the test duration given in Table 18. The voltage given in Table 18 shall be applied to the capacitors connected to 100 k Ω resistors and those connected to 6,8 k Ω resistors. In both cases, the voltage shall be applied across the capacitor/resistor combination.

Care shall be taken to avoid condensation of water on the capacitors or substrates. This ~~may~~ can happen if the door is opened during the test before the humidity is lowered.

Table 18 – Conditioning

Connected resistors kΩ	Applied voltage	Duration
100	(1,5 ± 0,1) V or the voltage specified in the detail specification	168 h, 500 h or 1 000 h; as specified in the detail specification
6,8	(50 ± 0,1) V or U_R , whichever is the lower, or the voltage specified in the detail specification	

5.19.4 Recovery

The applied voltage shall be disconnected, and the capacitors and resistors shall be removed from the test chamber and allowed to recover for 6 h to 24 h in standard atmospheric conditions for testing.

5.19.5 Final measurements

The capacitors shall be measured for insulation resistance, as in 5.19.2.

The insulation resistance, including the series resistor, shall be greater than 0,1 times the values given in 5.19.2.

6 Marking

6.1 General

See IEC 60384-1:2016/2021, 4.3, with the details of 6.2 to 6.6.

6.2 Information for marking

The information given in the marking is normally selected from the following list: the relative importance of each item is indicated by its position in the list:

- nominal capacitance;
- rated voltage (DC voltage may be indicated by the symbol: $\overline{\text{---}}$ [IEC 60417-5031(2002-10)] or ---);
- tolerance on nominal capacitance;
- temperature coefficient and its tolerance as applicable (in accordance with 4.2.5) or Annex B;
- year and month (or week) of manufacture;
- manufacturer's name or trade mark;
- climatic category;
- manufacturer's type designation;
- reference to the detail specification.

6.3 Marking on the body

These capacitors are generally not marked on the body. If some marking can be applied, they shall be clearly marked with as many as possible of the items stated in 6.2 as is considered useful. Any duplication of information in the marking on the capacitor should be avoided.

6.4 Requirements for marking

Any marking shall be legible and not easily smeared or removed by rubbing with fingers.

6.5 Marking of the packaging

The packaging containing the capacitor(s) shall be clearly marked with all the information listed in 6.2.

6.6 Additional marking

Any additional marking shall be so applied that no confusion can arise.

7 Information to be given in a detail specification

7.1 General

The detail specification shall be derived from the relevant blank detail specification.

Detail specifications shall not specify requirements inferior to those of the generic, sectional or blank detail specification. When more severe requirements are included, they shall be ~~listed in 4.9 of the detail specification and~~ indicated in the test schedules, for example by an asterisk.

The information given in 7.2 may be presented in tabular form if more convenient.

The information in 7.2 to 7.5 shall be given in each detail specification and the values quoted should be selected from those given in the appropriate clause of this document.

7.2 Outline drawing and dimensions

There shall be an illustration of the capacitors as an aid to easy recognition and for comparison of the capacitors with others.

Dimensions and their associated tolerances, which affect interchangeability and mounting, shall be given in the detail specification. All dimensions shall be stated in millimetres; however, when the original dimensions are given in inches, the converted metric dimensions in millimetres shall be added.

Normally the numerical values shall be given for the length, width and height of the body. When necessary, for example when a number of items (sizes and capacitance/voltage ranges) are covered by a detail specification, the dimensions and their associated tolerances shall be placed in a table below the drawing.

When the configuration is other than described above, the detail specification shall state such dimensional information as will adequately describe the capacitors.

7.3 Mounting

The detail specification shall give guidance on methods of mounting for normal use. Mounting for test and measurement purposes (when required) shall be in accordance with 5.4 of this document.

7.4 Rating and characteristics

7.4.1 General

The ratings and characteristics shall be in accordance with the relevant clauses of this document, together with 7.4.2, 7.4.3 and 7.4.4.

7.4.2 Nominal capacitance range

The nominal capacitance range shall be specified as described in 4.2.4.1.

When products approved to the detail specification have different ranges, the following statement should be added: "The range of capacitance values available in each voltage range is given in the register of approvals, available for example on the IECQ on-line certificate system website: www.iecq.org".

7.4.3 Particular characteristics

Additional characteristics may be listed when they are considered necessary to specify adequately the component for design and application purposes.

7.4.4 Soldering

The detail specification shall ~~prescribe~~ specify the test methods, severities and requirements applicable for the solderability and the resistance to soldering heat tests.

7.5 Marking

The detail specification shall specify the content of the marking on the capacitor and on the packaging. Deviations from Clause 6 shall be specifically stated in the detail specification.

8 Quality assessment procedures

8.1 Primary stage of manufacture

The primary stage of manufacture is the first common firing of the dielectric-electrode assembly.

8.2 Structurally similar components

Capacitors considered as being structurally similar are capacitors produced with similar processes and materials, though they ~~may~~ can be of different case sizes and values.

8.3 Certified records of released lots

The information required in IEC 60384-1:20162021, Q.1.5, shall be made available when ~~prescribed~~ specified in the detail specification and when requested by a purchaser. After the endurance test, the parameters for which variables information is required are the capacitance change, $\tan \delta$ and the insulation resistance.

8.4 Qualification approval

8.4.1 General

The procedures for qualification approval testing are given in IEC 60384-1:20162021, Clause Q.2.

The schedule to be used for qualification approval testing on the basis of lot-by-lot and periodic tests is given in Annex C. The procedure using a fixed sample size schedule is given in 8.4.2 and 8.4.3.

8.4.2 Qualification approval on the basis of the fixed sample size procedures

The fixed sample size procedure is described in IEC 60384-1:20162021, Q.2.4. The sample shall be representative of the range of capacitors for which approval is sought. This range may ~~or may not~~ be different from the complete range covered by the detail specification.

For each temperature coefficient, the sample shall consist of specimens of capacitors of maximum and minimum size and for each of these sizes, the maximum capacitance value for the highest rated voltage and minimum rated voltage of the voltage ranges for which approval is sought. When there are more than four rated voltages, an intermediate voltage shall also be tested. Thus, for the approval of a range, testing is required of either four or six values (capacitance/voltage combinations) for each temperature coefficient. Where the total range consists of fewer than four values, the number of specimens to be tested shall be that required for four values. When approval is sought for more than one temperature coefficient, see 8.4.3.

In case assessment level EZ is used, spare specimens are permitted as follows:

Two (for six values) or three (for four values) per value may be used as replacements for specimens that are non-conforming because of incidents not attributable to the manufacturer.

The numbers given in Group 0 assume that all groups are applicable. If this is not so, the numbers may be reduced accordingly.

When additional groups are introduced into the qualification approval test schedule, the number of specimens required for Group 0 shall be increased by the same number as that required for the additional groups.

Table 4 gives the number of samples to be tested in each group or subgroup together with the number of permissible non-conformances for the qualification approval test.

8.4.3 Tests

The complete series of tests specified in Table 19 and Table 20 are required for the approval of capacitors covered by one detail specification. The tests of each group shall be carried out in the order given.

The whole sample shall be subjected to the tests of Group 0 and then divided for the other groups.

Non-conforming specimens found during the tests of Group 0 shall not be used for the other groups.

"One non-conforming item" is counted when a capacitor has not satisfied the whole or a part of the tests of a group.

When approval is sought for more than one temperature coefficient at the same time, the test schedule and sample size required for the smallest temperature coefficient are those of Groups 1, 2 and 3. For each additional temperature coefficient, the testing is limited to the tests and sample sizes as specified for Subgroup 3.3 and Group 4.

The approval is decided on an individual temperature coefficient basis in accordance with the permissible number of non-conforming items indicated in Table 4. In order to calculate the total actual non-conforming items for temperature coefficients other than the smallest, the non-conforming items in Groups 1, 2 and 3 for the smallest temperature coefficient are added to the non-conforming items in Subgroup 3.3 and Group 4 for that particular temperature coefficient.

The approval is granted when the number of non-conforming items is zero.

Table 19 and Table 20 together form the fixed sample size test schedule. Table 4 includes the details for the sampling and permissible non-conforming items for the different tests or groups of tests. Table 5 together with the details of the test contained in Clause 8 gives a complete summary of test conditions and performance requirements and indicates where, for example for the test method or conditions of test, a choice shall be made in the detail specification.

The conditions of test and performance requirements for the fixed sample size test schedule shall be identical to those ~~prescribed~~ specified in the detail specification for quality conformance inspection.

**Table 19 – Fixed sample size test plan for qualification approval
Assessment level EZ**

Group No.	Test	Subclause of this publication	Number of specimens n^e	Permissible number of nonconforming items c
0	Visual examination	5.5	132 + 24 ^f	0
	Dimensions	5.5		
	Capacitance	5.6.1		
	Tangent of loss angle	5.6.2		
	Insulation resistance	5.6.3		
	Voltage proof	5.6.4		
	Spare specimens		12	
1A	Robustness of termination ^g	5.16	12	0
	Resistance to soldering heat	5.10		
	Component solvent resistance ^b	5.17		
1B	Solderability	5.11	12	0
	Solvent resistance of marking ^b	5.18		
2	Substrate bending test ^d	5.9	12	0
3 ^a	Mounting	5.4	84 + 24 ^f	0 ^c
	Visual examination	5.5		
	Capacitance	5.6.1		
	Tangent of loss angle	5.6.2		
	Insulation resistance	5.6.3		
	Voltage proof	5.6.4		
3.1	Shear test ^h	5.8	24	0
	Rapid change of temperature	5.12		
	Climatic sequence	5.13		
3.2	Damp heat, steady state	5.14	24	0
3.3	Endurance	5.15	36	0
3.4	Accelerated damp heat, steady state ^b	5.19	24 ^f	0
4	Temperature coefficient and temperature ~~cycle~~ cyclic drift	5.7	12	0

- ^a The values of these measurements serve as initial measurements for the tests of Group 3.
- ^b If required in the detail specification.
- ^c The capacitors found non-conforming items after mounting shall not be taken into account when calculating the permissible non-conforming for the following tests. They shall be replaced by spare capacitors.
- ^d Not applicable to capacitors, which, in accordance with their detail specification, shall only be mounted on alumina substrates.
- ^e Capacitance/voltage combinations, see 8.4.2.
- ^f Additional capacitors, if Group 3.4 is tested.
- ^g Applicable to capacitors with strip terminations.
- ^h Not applicable to capacitors with strip terminations.

Table 20 – Tests schedule for qualification approval

Subclause-number and test (see NOTE 1)	D or ND	Conditions of test (see NOTE 1)	Number of specimens (#) and number of non-conforming items (c)	Performance requirements (see NOTE 1)
GROUP 0 ~~8.5 Visual examination~~ ~~8.5 Dimension (detail)~~ ~~8.6.1 Capacitance~~ ~~8.6.2 Tangent of loss angle (tan δ)~~ ~~8.6.3 Insulation resistance~~ ~~8.6.4 Voltage proof~~	ND	~~Frequency: ... Hz~~ ~~Measuring voltage: ... V RMS~~ ~~Frequency and Measuring voltage same as in 8.6.1~~ ~~See detail specification for the method~~ ~~See detail specification for the method~~	See Table 4	~~As in 8.5.3~~ ~~Legible marking and as specified in the detail specification~~ ~~See the detail specification~~ ~~Within specified tolerance~~ ~~As in 8.6.2.3~~ ~~As in 8.6.3.4~~ ~~No breakdown or flashover~~
GROUP 1A ~~8.16 Robustness of termination (if applicable)~~ ~~8.10.2 Initial measurement~~ ~~8.10 Resistance to soldering heat~~ ~~8.10.5 Final measurement~~ ~~8.17 Component solvent resistance (if required)~~	D	~~Test Ua₄, Force: 2,5 N~~ ~~Test Ub, Method 1, Force: 2,5 N~~ ~~Number of bends: 4~~ ~~Visual examination~~ ~~Capacitance~~ ~~See detail specification for the method~~ ~~Recovery: 6 h to 24 h~~ ~~Visual examination~~ ~~Capacitance~~ ~~Solvent: ...~~ ~~Solvent temperature: ...~~ ~~Method 2~~ ~~Recovery: ...~~	See Table 4	~~No visible damage~~ ~~As in 8.10.5~~ ~~As in 8.10.5~~ ~~See detail specification~~

Subclause number and test (see NOTE 1)	D or ND	Conditions of test (see NOTE 1)	Number of specimens (#) and number of non-conforming items (c)	Performance requirements (see NOTE 1)
~~8.13.4 — Damp heat, cyclic, test Db, first cycle~~ ~~8.13.5 — Cold~~ ~~8.13.6 — Damp heat, cyclic, test Db, remaining cycles~~		~~Temperature: lower category temperature~~ ~~Duration: 2 h~~ ~~Visual examination~~ ~~Recovery: 6 h to 24 h~~		No visible damage
8.13.7 — Final measurements		~~Visual examination~~ ~~Capacitance~~ ~~Tangent of loss angle~~ ~~Insulation resistance~~		~~No visible damage~~ ~~Legible marking~~ ~~As in 8.13.7~~ ~~As in 8.13.7~~ ~~As in 8.13.7~~
GROUP 3.2 ~~8.14 — Damp heat, steady-state~~ ~~8.14.2 Initial measurement~~ ~~8.14.5 Final measurements~~	D	~~Capacitance~~ ~~Recovery: 6 h to 24 h~~ ~~Visual examination~~ ~~Capacitance~~ ~~Tangent of loss angle~~ ~~Insulation resistance~~	See Table 4	~~No visible damage~~ ~~Legible marking~~ ~~As in 8.14.5~~ ~~As in 8.14.5~~ ~~As in 8.14.5~~
GROUP 3.3 ~~8.15 — Endurance~~ ~~8.15.2 Initial measurement~~ ~~8.15.5 Final measurements~~	D	~~Duration: ... h~~ ~~Temperature: ... °C~~ ~~Voltage: ... V~~ ~~Capacitance~~ ~~Recovery: 6 h to 24 h~~ ~~Visual examination~~ ~~Capacitance~~ ~~Tangent of loss angle~~ ~~Insulation resistance~~	See Table 4	~~No visible damage~~ ~~Legible marking~~ ~~As in 8.15.5~~ ~~As in 8.15.5~~ ~~As in 8.15.5~~
Group 3.4 ~~8.19 — Accelerated damp heat, steady-state (if required)~~ ~~8.19.2 — Initial measurement~~ ~~8.19.5 — Final measurement~~	D	~~Duration: ... h~~ ~~Temperature: (85 ± 2) °C~~ ~~Humidity: (85 ± 3) % RH~~ ~~Insulation resistance~~ ~~Recovery: 6 h to 24 h~~ ~~Insulation resistance~~	See Table 4	~~As in 8.19.2~~ ~~As in 8.19.5~~
Group 4	ND		See Table 4	

Subclause number and test (see NOTE 1)	D or ND	Conditions of test (see NOTE 1)	Number of specimens (n) and number of non-conforming items (c)	Performance requirements (see NOTE 1)
8.7 ——— Temperature coefficient and cyclic ——— drift		Preliminary drying: ——— 16 h to 24 h		As in 8.7.4
NOTE 1 — Subclause numbers of test and performance requirements refer to Clause 8.				
NOTE 2 — In this table: D – destructive, ND – non-destructive.				
^a — This test may be carried out on capacitors mounted on a substrate. ^b — When different substrate materials are used for the individual subgroup, the detail specification shall indicate which substrate material is used in each subgroup.				

Test (see NOTE 1)	Conditions of test (see NOTE 1)	D or ND (see NOTE 2)	n c (see Table 19)	Performance requirements (see NOTE 1)
GROUP 0		ND	See Table 19	
5.5 Visual examination				As in 5.5.3
5.5 Dimension (detail)				Legible marking and as specified in the detail specification
5.6.1 Capacitance	Frequency: ... Hz Measuring voltage: V RMS			See the detail specification
5.6.2 Tangent of loss angle (tan δ)	Frequency and Measuring voltage same as in 5.6.1			Within specified tolerance
5.6.3 Insulation resistance	See detail specification for the method			As in 5.6.2.3
5.6.4 Voltage proof	See detail specification for the method			As in 5.6.3.4
				No breakdown or flashover
GROUP 1A		D	See Table 19	
5.16 Robustness of termination (if applicable)	Test U _{a1} , Force: 2,5 N Test U _b , Method 1, Force: 2,5 N Number of bends: 1			
	Visual examination			No visible damage
5.10.2 Initial measurement	Capacitance			
5.10 Resistance to soldering heat	See detail specification for the method			
	Recovery: 6 h to 24 h			
5.10.5 Final inspection, measurements and requirements	Visual examination Capacitance			As in 5.10.5
5.17 Component solvent resistance (if required)	Solvent: ... Solvent temperature: Method 2 Recovery: ...			As in 5.10.5
				See detail specification
GROUP 1B		D	See Table 19	

Test (see NOTE 1)		Conditions of test (see NOTE 1)	D or ND (see NOTE 2)	<i>n</i> <i>c</i> (see Table 19)	Performance requirements (see NOTE 1)
5.11	Solderability	See detail specification for the method			
5.11.4	Final inspection, measurements and requirements	Visual examination			As in 5.11.4
5.18	Solvent resistance of the marking ^a (if required)	Solvent: ... Solvent temperature: ... Method 1 Rubbing material: cotton wool Recovery: ...			Legible marking
GROUP 2			D	See Table 19	
5.9	Substrate bending test	Deflection: ... Number of bends: ...			See detail specification
5.9.2	Initial measurement	Capacitance			
5.9.3	Final inspection	Capacitance (with printed board in bent position) Visual examination			$ \Delta C/C \leq 5\%$ No visible damage
GROUP 3			D	See Table 19	
5.4	Mounting	Substrate material: ... ^b Visual examination Capacitance Tangent of loss angle Insulation resistance Voltage proof			As in 5.5.3 Within specified tolerance As in 5.6.2.3 As in 5.6.3.4 No breakdown or flashover
GROUP 3.1			D	See Table 19	
5.8	Shear test	Visual examination			No visible damage
5.12.2	Initial measurement	Capacitance			
5.12	Rapid change of temperature	T_A = Lower category temperature T_B = Upper category temperature Five cycles Duration t_1 = 30 min Recovery: 6 h to 24 h			
5.12.5	Final inspection, measurements and requirements	Visual examination Capacitance			No visible damage $\Delta C/C$: as in 5.12.5
5.13	Climatic sequence				
5.13.2	Initial Measurement	Capacitance			
5.13.3	Dry heat	Temperature: upper category temperature Duration: 16 h			
5.13.4	Damp heat, cyclic, test Db, first cycle				
5.13.5	Cold	Temperature: lower category temperature Duration: 2 h			

Test (see NOTE 1)	Conditions of test (see NOTE 1)	D or ND (see NOTE 2)	<i>n</i> (see Table 19)	<i>c</i> (see Table 19)	Performance requirements (see NOTE 1)
5.13.6 Damp heat, cyclic, test Db, remaining cycles 5.13.7 Final inspection, measurements and requirements	Visual examination Recovery: 6 h to 24 h Visual examination Capacitance Tangent of loss angle Insulation resistance				No visible damage No visible damage Legible marking $\Delta C/C$: as in 5.13.7 As in 5.13.7 As in 5.13.7
GROUP 3.2 5.14 Damp heat, steady state 5.14.2 Initial measurement 5.14.5 Final inspection, measurements and requirements	Capacitance Recovery: 6 h to 24 h Visual examination Capacitance Tangent of loss angle Insulation resistance	D	See Table 19		No visible damage Legible marking $\Delta C/C$: as in 5.14.5 As in 5.14.5 As in 5.14.5
GROUP 3.3 5.15 Endurance 5.15.2 Initial measurement 5.15.5 Final inspection, measurements and requirements	Duration: ... h Temperature: ... °C Voltage: ... V Capacitance Recovery: 6 h to 24 h Visual examination Capacitance Tangent of loss angle Insulation resistance	D	See Table 19		No visible damage Legible marking $\Delta C/C$: as in 5.15.5 As in 5.15.5 As in 5.15.5
GROUP 3.4 5.19 Accelerated damp heat, steady state (if required) 5.19.2 Initial measurement 5.19.5 Final measurement	Duration: ... h Temperature: (85 ± 2) °C Humidity: (85 ± 3) % RH Insulation resistance Recovery: 6 h to 24 h Insulation resistance	D	See Table 19		As in 5.19.2 As in 5.19.5
GROUP 4 5.7 Temperature coefficient (<i>a</i>) and temperature cyclic drift	Primary drying: 16 h to 24 h	ND	See Table 19		$\Delta C/C$: as in 5.7.4

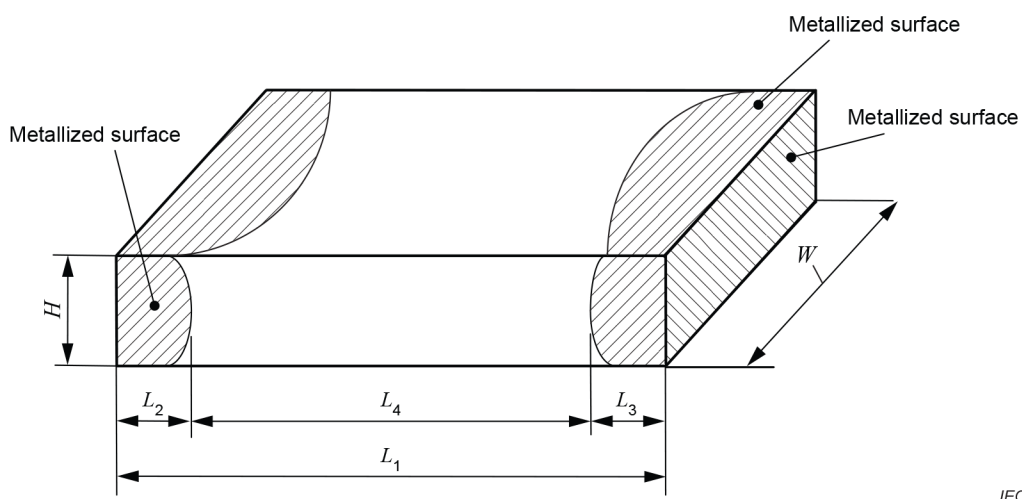
Test (see NOTE 1)	Conditions of test (see NOTE 1)	D or ND (see NOTE 2)	<i>n</i> (see Table 19)	<i>c</i>	Performance requirements (see NOTE 1)
NOTE 1 Subclause numbers of test and performance requirements refer to Clause 5.					
NOTE 2 In this table: D = destructive, ND= non-destructive.					
^a This test may be carried out on capacitors mounted on a substrate.					
^b When different substrate materials are used for the individual subgroup, the detail specification shall indicate which substrate material is used in each subgroup.					

Annex A (normative)

Guidance for the specification and coding of dimensions of fixed surface mount multilayer capacitors of ceramic dielectric, Class 1

The principles given in Figure A.1 ~~should~~ shall be considered in the dimensioning of the capacitors.

Dimensions are specified in Table A.1.



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Dimension W should not exceed dimension L_1 .

Dimension H should not exceed dimension W .

If necessary, the thickness of tinning should be specified.

Figure A.1 – Dimensions

Table A.1 – Dimensions

Code	Length L_1	Width W	$L_2; L_3$ Minimum	L_4 Minimum
0201M	$0,25 \pm 0,013$	$0,125 \pm 0,013$	0,04	0,06
0402M	$0,4 \pm 0,02$	$0,2 \pm 0,02$	0,05	0,1
0603M	$0,6 \pm 0,03$	$0,3 \pm 0,03$	0,1	0,2
1005M	$1,0 \pm 0,05$	$0,5 \pm 0,05$	0,1	0,3
1608M	$1,6 \pm 0,1$	$0,8 \pm 0,1$	0,2	0,5
2012M	$2,0 \pm 0,1$	$1,25 \pm 0,1$	0,2	0,7
3216M	$3,2 \pm 0,2$	$1,6 \pm 0,15$	0,3	1,4
3225M	$3,2 \pm 0,2$	$2,5 \pm 0,2$	0,3	1,4
4532M	$4,5 \pm 0,3$	$3,2 \pm 0,2$	0,3	2,0
5750M	$5,7 \pm 0,4$	$5,0 \pm 0,4$	0,3	2,5
NOTE Dimension in millimetres.				

Other case sizes and dimensions may be specified in the detail specification.

Annex B

(informative normative) 4

Combination of temperature coefficients and tolerances
for the reference temperature of 25 °C

~~The temperature coefficient of capacitance for the reference temperature of 25 °C has often been used due to marketing needs and because of their actual performance.~~

Temperature coefficients of capacitance, tolerances and related codes are shown in Table B.1.

Table B.1 – Combination of temperature coefficients and tolerances
for the reference temperature of 25 °C

Code of temperature coefficient and tolerance	Temperature coefficient and the tolerance		Permissible relative variation in capacitance in parts per 1 000 between 25 °C and given temperature							
			Lower category temperature				Upper category temperature			
	α 10 ⁻⁶ /K	Tolerance 10 ⁻⁶ /K	-55 °C	-40 °C	-25 °C	-10 °C	+70 °C	+85 °C	+100 °C	+125 °C
C0G	0	± 30	-2,40/ 5,81	-1,95/ 4,72	-1,50/ 3,63	-1,05/ 2,54	-1,35/ 1,35	-1,80/ 1,80	-2,25/ 2,25	-3,00/ 3,00
U2J	-750	±120	50,4/ 87,8	41,0/ 71,3	31,5 /54,9	22,1/ 38,4	-39,2/ -28,4	-52,2/ -37,8	-65,3/ -47,3	-87,0/ -63,0
α = nominal temperature coefficient										
NOTE C0G and U2J (Code of temperature coefficient and tolerance), see EIA-198-1-F.										